

## DENSITY AND DIVERSITY OF NONTARGET INSECTS KILLED BY SUBURBAN ELECTRIC INSECT TRAPS<sup>1</sup>

Timothy B. Frick, Douglas W. Tallamy<sup>2</sup>

**ABSTRACT:** Our survey of insects electrocuted during routine use of electric insect traps revealed only 31 biting flies, a minute proportion (0.22%) of the 13,789 total insects counted. In contrast, species from 12 orders and more than 104 nontarget insect families, including 1,868 predators and parasites (13.5%) and 6,670 nonbiting aquatic insects (48.4%) were destroyed. The heavy toll on nontarget insects and the near absence of biting flies in catches suggests that electric insect traps are worthless for biting fly reduction — and probably are counterproductive — to homeowners and other consumers.

Electric insect traps (*e.g.*, Zapper™, Bugwacker™ and Bug Blaster™; hereafter, “zappers”) use ultraviolet light to lure flying insects toward an electrified metal grid, where they are destroyed by the thousands on warm summer nights. Homeowners buy traps to rid their surroundings of annoying biting flies, and continuous snaps, crackles, and pops emanating from an active zapper seem to confirm their effectiveness. Traps are commonly used near aquatic habitats, waterfront areas, toll booths, campgrounds, industrial parks, restaurants, swimming pools, and suburban backyards. In suburban yards, traps are often run throughout the summer months, some only during the evening hours and some continually.

Although the target insects are primarily mosquitoes (*Culicidae*) and no-see-ums (*Ceratopogonidae*) that seek blood meals at the expense of homeowners, several factors make electric traps ineffective in reducing local mosquito populations (Surgeoner & Helson 1977, Nasci *et al.* 1983). Ultraviolet lamps that emit considerable amounts of visible light (as do the lamps sold in commercial electric traps) are less attractive to mosquitoes than lamps emitting only ultraviolet wavelengths (Ikeuchi 1967). Furthermore, many species of mosquitoes are not attracted to light traps at all (Pippin 1965, Miller *et al.* 1969) and those species that are are often not trapped in numbers proportionate to their population sizes (Bradley 1943, Huffaker & Back 1943, Fox 1958). But perhaps the most important reasons electric insect traps fail to reduce mosquito problems are that 1) carbon dioxide exhaled by homeowners is far more attractive to mosquitoes than are light traps (Headlee 1941, Huffaker & Back 1943, Nasci *et al.* 1983), and 2) mosquitoes that do move toward traps are rarely killed by electrocution devices (Service 1993).

<sup>1</sup> Received August 18, 1995. Accepted September 21, 1995.

<sup>2</sup> Department of Entomology and Applied Ecology, Delaware Agricultural Experiment Station, College of Agricultural Sciences, University of Delaware, Newark, Delaware 19717-1303.

Electric insect traps are, however, effective at killing large numbers of nontarget insects. Nasci *et al.* (1983) found that the average zapper in South Bend, Indiana killed more than 3000 insects per day, 96.7% of which were not female mosquitoes. Little beyond ordinal totals is known about the diversity and seasonal distribution of nontarget insects killed by zappers. As an initial step toward understanding the ecological consequences of indiscriminant removal by zappers of nontarget predators, parasitoids, and prey species from aquatic and terrestrial ecosystems, we quantified at the family level the numbers and kinds of insects killed over a season by homeowners' zappers in a suburban setting.

## MATERIALS AND METHODS

We asked six homeowners with active bug zappers in suburban Newark, Delaware to participate in a summer-long study in 1994. All houses were within 3 km of a body of water. The house closest to water was about 65 meters from a large stream containing many stagnant eddies. Another house abutted a wooded area and was less than 1 km from a creek. The third house was about 1.5 km from the same creek but farther upstream. The fourth was in a wooded cul-de-sac through which ran a different creek; several permanent pools lay within 200 meters. The fifth house was situated in a residential development containing a stream and scattered wooded areas; a small pond about 30 meters long and 15 meters wide was less than a kilometer away. A small stream about 3 km distant was the nearest body of permanent water to the sixth house. Temporary pools, tree holes and water-filled containers were scattered throughout the study area. Thus, all traps were well within flight range of culicid and ceratopogonid breeding sites.

From June 20 to July 9, 1994, homeowners were asked to run the traps one night per week for at least two hours. Beginning on July 10, participants were asked to run their zappers one night per week every other week for the nine weeks ending August 27. A device constructed from a plastic dish 32 centimeters in diameter was suspended beneath each trap to collect electrocuted insects. Each morning after the traps were run, we collected the samples from the six sites and stored them in a freezer until they could be counted and identified to family (except for Ephemeroptera, Psocoptera, Thysanoptera, and Trichoptera, which were identified only to order, and several families of moths, which were grouped as "Microlepidoptera").

## RESULTS

We collected 31 samples from the traps over our ten-week study period in the summer of 1994. Nearly all electrocuted specimens, including the tiniest

Cecidomyiidae, were well-preserved and easily identified. Twelve orders and more than 104 families were present in these samples and ranged in abundance from a single individual (several families) to more than 4,600 individuals (Chironomidae; Table 1). Of the 13,789 insects killed by electric zappers in our study, only 31 individuals (0.22%) were biting flies (female Culicidae, Simuliidae, and Ceratopogonidae). In contrast, insect predators, parasitoids, and nonbiting aquatic insects were abundant (Table 1). Present in our counts were representatives of 27 families of predators and nine families of parasitoids, totaling 1,868 individuals (13.5%). Carabid beetles, staphylinid beetles, cicadellid leafhoppers, microlepidoptera, and braconid parasitoids were particularly common victims. Large numbers of aquatic insects, such as caddisflies (Trichoptera) and midges (Chironomidae), were also destroyed; species from these families represented nearly half (48.4%) of sample totals.

Average numbers of insects per trap declined sharply over the season (Fig. 1), ranging from a mean of 1,304 insects per trap on June 20 to just 106 insects per trap on August 27. This probably reflects seasonal declines in the popula-

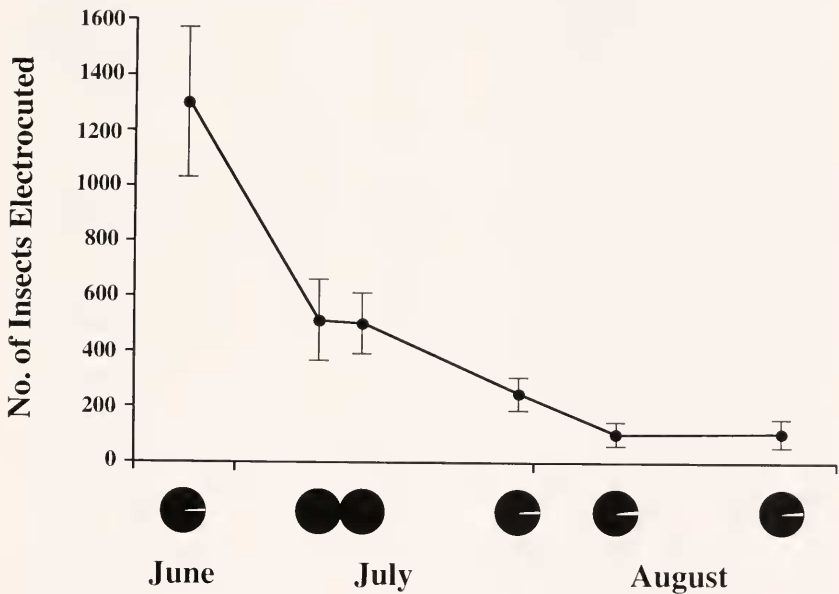


Fig. 1. Seasonal pattern of insects killed at six electric insect traps in Newark, DE on six dates from June 20 to August 27, 1994. Statistical interval = Standard Error. Pie charts depict the percentage of the total catch consisting of nontarget insects (black portion) and biting flies (white portion) on each trapping date

tions of species attracted to these traps. Although biting insects generally increased in proportion as the season progressed (from 0.26% of the total catch on June 20 to 1.88% on August 20), they still comprised a minuscule portion of the total sample.

## DISCUSSION

These data are straightforward: many thousands of nontarget insects representing a rich taxonomic diversity were destroyed by these traps. Only a tiny fraction of trap victims were biting flies, the primary targets of electric zappers. Since we did not independently measure mosquito populations in our study sites we cannot definitively conclude that the zappers used in our study were ineffective mosquito killers. However, three types of circumstantial evidence suggest that this was indeed the case. First, it is highly unlikely that our lowland, wooded sites which were rich in aquatic breeding habitats, produced so few adult mosquitoes in the course of 9 weeks that 18 electrocuted females would represent adequate control of these flies. Second, the preponderance of aquatic insects in the samples suggests that our study traps were well within the flight range of biting flies that breed in water (culicids, ceratopogonids). Finally, our results are similar to those of Nasci *et al.* (1983) in which an independent measure of culicid populations confirmed the inability of zappers to attract mosquitoes that are present in suburban settings.

As we better understand the critical role insects play in the cohesion of most non-marine ecosystems, the sale and use of electric insect traps that so completely miss their advertised mark becomes increasingly irresponsible. It is insects and other invertebrates, not vertebrates, that are the "glue" of ecosystems; their elimination would inevitably lead to the rapid demise of those ecosystems and their members, including *Homo sapiens* (Wilson 1987). Even if targeted biting flies were effectively controlled by electric zappers, the resulting destruction of thousands of parasitoids, predators, aquatic insects, and other members of the nocturnally active fauna would be difficult to justify.

Although we recognize its speculative shortcomings, a simple calculation underscores the degree to which electric zappers may affect nontarget insect populations. The seasonal mean catch per night (of at least 2 hr of trap time) as quantified by our study totaled 445 insects per trap. Approximately one million zappers are sold in the U.S. each year (Philadelphia Inquirer, 26 June 1995 p. 63). Electrocution devices are quite durable; the homeowners in our study had been operating their units for an average of 7 yrs prior to 1994. If, in any given year, 4 million traps are used for 40 nights during the summer, then 71,200,000,000 — more than **71 billion** nontarget insects — are needlessly destroyed in the U.S. each year by misinformed homeowners. If we substitute into our calculations the trap means obtained by Nasci *et al.* (1983) in Indiana (2163 insects during a 2 h trapping period; N = 10), this figure rises to nearly

Table 1. Seasonal totals of biting flies (in **bold**), predators and parasitoids (*italicized*), plus other taxa killed by electric insect traps at six sites in Newark, DE.

<i>Order and Family</i>	<i>No.</i> <i>Killed</i>	<i>% of</i> <i>Total</i>	<i>Order and Family</i>	<i>No.</i> <i>Killed</i>	<i>% of</i> <i>Total</i>
<b>Ephemeroptera</b> .....	15	0.11	<i>Mycetophilidae</i> .....	34	0.25
<b>Dermaptera</b>			<i>Anisopodidae</i> .....	13	0.09
<i>Labidae</i> .....	2	0.02	<i>Sciaridae</i> .....	89	0.65
<b>Psocoptera</b> .....	14	0.10	<i>Dixidae</i> .....	3	0.02
<b>Hemiptera</b>			<i>Cecidomyiidae</i> .....	316	2.29
<i>Corixidae</i> .....	10	0.07	<i>Stratiomyidae</i> .....	5	0.04
<i>Hebridae</i> .....	2	0.02	<i>Xylophagidae</i> .....	1	0.01
<i>Miridae</i> .....	89	0.64	<i>Asilidae</i> .....	1	0.01
<i>Nabidae</i> .....	2	0.02	<i>Scenopinidae</i> .....	1	0.01
<i>Lygaeidae</i> .....	32	0.23	<i>Rhagionidae</i> .....	2	0.02
<i>Rhopalidae</i> .....	1	0.01	<i>Empididae</i> .....	58	0.42
<i>Cydnidae</i> .....	14	0.10	<i>Dolichopodidae</i> .....	70	0.51
<b>Homoptera</b>			<i>Pipunculidae</i> .....	1	0.01
<i>Cicadidae</i> .....	33	0.24	<i>Phoridae</i> .....	12	0.09
<i>Cicadellidae</i> .....	2421	17.56	<i>Platypezidae</i> .....	4	0.03
<i>Flatidae</i> .....	8	0.05	<i>Otitidae</i> .....	2	0.02
<i>Acanaloniidae</i> .....	1	0.01	<i>Tephritidae</i> .....	2	0.02
<i>Psyllidae</i> .....	41	0.30	<i>Sciomyzidae</i> .....	1	0.01
<i>Delphacidae</i> .....	1	0.01	<i>Ephydriidae</i> .....	8	0.05
<i>Cixiidae</i> .....	1	0.01	<i>Drosophilidae</i> .....	7	0.05
<i>Aphididae</i> .....	25	0.18	<i>Agromyzidae</i> .....	14	0.10
<b>Thysanoptera</b> .....	16	0.12	<i>Lonchaeidae</i> .....	5	0.04
<b>Neuroptera</b>			<i>Lonchopteridae</i> .....	8	0.05
<i>Corydalidae</i> .....	1	0.01	<i>Heleomyzidae</i> .....	1	0.01
<i>Chrysopidae</i> .....	8	0.05	<i>Sphaeroceridae</i> .....	2	0.02
<b>Coleoptera</b>			<i>Anthomyiidae</i> .....	28	0.20
<i>Carabidae</i> .....	661	4.79	<i>Calliphoridae</i> .....	17	0.12
<i>Dytiscidae</i> .....	21	0.15	<i>Sarcophagidae</i> .....	8	0.05
<i>Hydrophilidae</i> .....	83	0.60	<i>Tachinidae</i> .....	16	0.12
<i>Staphylinidae</i> .....	306	2.22	<b>Trichoptera</b> .....	1597	11.58
<i>Lucanidae</i> .....	1	0.01	<b>Lepidoptera</b>		
<i>Scarabaeidae</i> .....	219	1.58	<i>Microlepidoptera</i> ...	1121	8.13
<i>Buprestidae</i> .....	3	0.02	<i>Tortricidae</i> .....	19	0.14
<i>Elateridae</i> .....	46	0.33	<i>Pyralidae</i> .....	316	2.29
<i>Lampyridae</i> .....	12	0.09	<i>Geometridae</i> .....	35	0.25
<i>Cantharidae</i> .....	104	0.754	<i>Lasiocampidae</i> .....	3	0.02
<i>Dermestidae</i> .....	11	0.08	<i>Arctiidae</i> .....	11	0.08
<i>Anobiidae</i> .....	30	0.22	<i>Noctuidae</i> .....	64	0.46
<i>Cleridae</i> .....	4	0.03	<i>Notodontidae</i> .....	2	0.02
<i>Nitidulidae</i> .....	27	0.20	<i>Epipyropidae</i> .....	5	0.04
<i>Coccinellidae</i> .....	15	0.11	<i>Yponomeutidae</i> .....	10	0.07
<i>Tenebrionidae</i> .....	13	0.09	<b>Hymenoptera</b>		
<i>Mordellidae</i> .....	10	0.07	<i>Braconidae</i> .....	377	2.73
<i>Cerambycidae</i> .....	11	0.08	<i>Ichneumonidae</i> .....	77	0.56
<i>Chrysomelidae</i> .....	22	0.16	<i>Mymaridae</i> .....	1	0.01
<i>Curculionidae</i> .....	7	0.05	<i>Perilampidae</i> .....	1	0.01
<i>Scolytidae</i> .....	27	0.20	<i>Eulophidae</i> .....	1	0.01
<b>Diptera</b>			<i>Encyrtidae</i> .....	1	0.01
<i>Tipulidae</i> .....	223	1.62	<i>Pteromalidae</i> .....	1	0.01
<i>Psychodidae</i> .....	11	0.08	<i>Torymidae</i> .....	2	0.02
<i>Culicidae</i> .....	♂ 25, ♀ 18	0.31	<i>Eurytomidae</i> .....	1	0.01
<i>Ceratopogonidae</i> .....	♂ 30, ♀ 12	0.30	<i>Chrysididae</i> .....	3	0.02
<i>Chironomidae</i> .....	4612	33.45	<i>Formicidae</i> .....	84	0.61
<i>Scatopsidae</i> .....	13	0.09	<i>Vespi.</i> .....	3	0.02
<i>Simuliidae</i> .....	1	0.01	<i>Halictidae</i> .....	1	0.01
<i>Bibionidae</i> .....	1	0.01			

*350 billion* nontarget insects. We suggest, therefore, that while there is no evidence that zappers control nuisance insects, their effects may be anything but benign. Studies investigating the effects of insect defaunation on local ecosystems in general and on specialized insectivores such as bats and nighthawks in particular are needed to evaluate the ecological costs of zappers and other human activities destructive to insects. The results of our study indicate that entomologists, especially those active in extension, should be educating the public about the possible costs and lack of benefits from these gadgets.

#### ACKNOWLEDGMENTS

We gratefully acknowledge the Aftosmis, Fanny, Cherwaty, Walter, White, and Hawthorne families, and C. J. Murphy and A. Schleiniger for their cooperative participation in our study. R. R. Roth, H. Frick, R. G. Weber, and C. Tallamy made helpful comments on the manuscript. Published as Paper No. 1557 of the Delaware Agricultural Experiment Station; Contribution No. 678 of the Department of Entomology and Applied Ecology.

#### LITERATURE CITED

- Bradley, G. H. 1943. Determination of densities of *Anopheles quadrimaculatus* on the wing. Proc. New Jersey Mosq. Exterm. Assoc. 30:22-27.
- Fox, I. 1958. The mosquitoes of the international airport, Isla Verde, Puerto Rico, as shown by light traps. Mosq. News 18:117-124.
- Headlee, T. J. 1941. New Jersey mosquito problems. Proc. New Jersey Mosq. Exterm. Assoc. 28:7-12.
- Huffaker, C. B., and R. C. Baek. 1943. A study of methods of sampling mosquito populations. J. Econ. Entomol. 36:561-569.
- Ikeuchi, M. 1967. Ecological studies on mosquitoes collected by light traps. Trop. Med. 9: 186-200.
- Miller, T. A., R. G. Stryker, R. N. Wilkinson, and S. Esah. 1969. Notes on the use of CO<sub>2</sub>-baited CDC miniature light traps for mosquito surveillance in Thailand. Mosq. News 29:688-689.
- Nasci, R. S., C. W. Harris, and C. K. Porter. 1983. Failure of an insect electrocuting device to reduce mosquito biting. Mosq. News 43:180-44.
- Pippin, W. F. 1965. Notes on the operation of a light trap in central Luzon, Philippine Islands. Mosq. News 25: 183-187.
- Service, M. W. 1993. *Mosquito ecology: field sampling methods*. 2nd edition. Elsevier Applied Science, New York, New York.
- Surgeoner, G. A., and B. V. Helson. 1977. A field evaluation of electrocutors for mosquito control in southern Ontario. Proc. Entomol. Soc. Ontario 108:53-58.
- Wilson, E. O. 1987. The little things that run the world (the importance and conservation of invertebrates). Conservation Biology 1:344-346.